CLAIMS

1. A method for the automated analysis of a digital image comprising an array of pixels, including the steps of:

(a) identifying the locations of objects within the image which have specified intensity and size characteristics;

(b) defining regions of specified extent within the image which contain respective said objects;

(c) deriving from the data within respective said regions one or more respective closed contours comprising points of equal intensities; and

(d) estimating the curvature of at least one respective said contour within respective said regions at least to produce a measure of any concavity thereof.

2. A method according to claim 1 wherein step (a) comprises the application of a radially-symmetric difference filter with zero mean.

3. A method according to claim 2 wherein the image is filtered at a plurality of resolutions of increasing scale.

4. A method according to claim 2 or claim 3 wherein said locations are identified in accordance with the locations of respective local extrema in the output of said filter.

5. A method according to claim 4 including the step of sorting, in order of intensity, local extrema in the output of said filter and selecting for further analysis only those objects which correspond to a specified proportion of said extrema in such order.

6. A method according to any preceding claim further comprising, following step (a):

selecting an intensity threshold related to the mean intensity of pixels within the image in neighbourhoods of said locations;

creating a binary image according to whether pixels in the first-mentioned image are above or below said threshold;

identifying regions in the binary image composed of connected pixels which are below said threshold in the first-mentioned image; and

rejecting from further analysis those objects which correspond to such regions in the binary image which fall below a specified size or thickness.

7. A method according to any preceding claim wherein step (c) comprises, for respective said regions, deriving respective first and second said contours having respectively lower and higher resolutions, determining whether the sizes and locations of said first and second contours are consistent within specified criteria and, if so consistent, selecting said second contour for step (d).

8. A method according to claim 7 wherein, for respective said regions, the first said contour is derived by:

seeking within the region one or more contours of respective specified intensities;

determining whether the or each such contour is a closed contour and meets specified location, size and/or intensity orientation criteria; and

if more than one such contour is a closed contour and meets such criteria, selecting from the same the contour of the lowest intensity.

9. A method according to claim 8 wherein said specified intensities are no greater than that which corresponds to the contour of highest edge strength within the respective region.

10. A method according to claim 9 when appended to any one of claims 2 to 5 wherein said first contour is derived by seeking one or more contours in the output of said filter for the respective region and said specified intensities are no greater than the zero level in such output.

11. A method according to any one of claims 8 to 10 wherein, for respective said regions, the second said contour is derived by:

seeking within the region a plurality of contours of respective specified intensities ranging between the lowest and highest intensities within the region;

determining whether each such contour is a closed contour and meets specified location, size and/or intensity orientation criteria; and

if more than one such contour is a closed contour and meets such criteria, selecting from the same the contour having the highest edge strength.

12. A method according to any preceding claim wherein step (d) includes the application of a Probability Density Association Filter to respective said contours.

13. A method according to any preceding claim wherein step (d) comprises, for respective said contours:

measuring the curvature of the contour at a plurality of points around the contour, convexity and concavity being of opposite sign;

setting convex values of such curvature to zero;

plotting resultant values of curvature at said points against a measure of the distance of the respective point along the contour; and

computing as said measure of concavity the line integral of such plot.

14. A method according to any preceding claim further comprising the step of:

(e) classifying objects into one of at least two classes in accordance with a function of said measure of concavity of a contour corresponding to the respective object and a measure of the mean intensity of the respective object.

15. A method according to claim 14 wherein step (e) is performed by use of a Fisher classifier.

16. A method according to claim 14 or claim 15 wherein the intensities of respective objects are normalised prior to step (e).

17. A method according to any one of claims 14 to 16 further comprising the step of:

(f) counting the number of objects classified into a specified one of said classes.

18. A method according to any preceding claim for the automated analysis of a digital image of a histological or cytology specimen.

19. A method according to claim 18 wherein the image is of a section of breast tissue.

20. A method according to claim 18 or claim 19 when appended to claim 17, wherein said specified class is identified as the class of mitotic epithelial cell nuclei.

21. A method according to any one of claims 1 to 17 for the automated analysis of a digital image of a soil sample.

22. A method for the automated identification of mitotic activity from a digital image of a histological specimen, including the steps of:

(a) identifying the locations of objects within the image which have specified intensity and size characteristics associated with epithelial cell nuclei;

(b) defining regions of specified extent within the image which contain respective said objects;

(c) deriving from the data within respective said regions one or more respective closed contours comprising points of equal intensities;

(d) estimating the curvature of at least one respective said contour within respective said regions at least to produce a measure of any concavity thereof; and

(e) classifying objects as representing mitotic cell nuclei as a function of at least said measure of concavity of a contour corresponding to the respective object.

23. Apparatus for the automated analysis of a digital image comprising means adapted to perform a method according to any preceding claim.

24. A computer program product comprising a computer readable medium having thereon computer program code means adapted to cause a computer to execute a method according to any one of claims 1 to 22.

25. A computer program comprising instructions to cause a computer to execute a method according to any one of claims 1 to 22.